6502 PERIPHERALS AND PRODUCTS

CATALOG A5

Spring 1980

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MICRO TECHNOLOGY UNLIMITED

Micro Technology Unlimited (MTU) was founded to bring high technology products and technical information to the market in easy to use form. Our present step towards this goal involves the design and sale of products based around the 6502 microprocessor. The price and performance of this processor are excellent while its advanced technical features allow us to build sophisticated products at very competitive prices. Our accessories in combination with any of the several excellent 6502 based systems on the market give computing/teaching power heretofore unavailable to those on restricted budgets. The principals of the company are Howard (Hal) A. Chamberlin and David B. Cox. These men have been cooperating in a synergistic manner for over a decade and have designed microcomputer based systems ever since the first microprocessor was introduced in 1972. The products offered in this catalog were developed with the above goal in mind. In addition to the advanced design concepts, thorough testing, and high performance of hardware and software products, we pride ourselves in detailed, accurate documentation. Our hardware products manuals include an extensive theory of operation section with timing diagrams and complete, easy to read schematic and parts list.

MANUALS — ADDITIONAL INFORMATION

For technical information beyond the product description sheets in this catalog we suggest purchase of the manual for the product in question. Its price will be credited toward purchase of the associated product hardware. Manuals include schematics, parts list and layout, principles of operation, troubleshooting guide, specifications, and a diagnostic program listing. If the manual does not answer a specific question or if you feel that your question is unlikely to be answered by the manual, please contact us. *Our manuals have been classed — BEST IN THE INDUSTRY.*

WARRANTY

All products of MTU are warranted for 6 months from date of shipment from the factory to be free of defective parts and workmanship. Any other damages including but not limited to: misuse, abuse, fire, flood, or other acts of God are not covered by this warranty. Units under warranty requiring repairs are to be returned to the factory postpaid. These will be returned postpaid within 2 weeks from the date of receipt. No statements other than these printed specifications are made or implied. Liability of MTU is limited to repair or replacement of faulty unit(s) and does not extend beyond the purchase of the unit(s).

Out of warranty repairs are available on the same schedule as listed above. Minimum charge for factory repairs is *$20.00* plus parts.

BARE BOARDS

Please note that bare boards are intended only for experienced persons with adequate test equipment. Although the technical documentation is excellent, it is not in the form of kitbuilding instructions. In all cases the availability of a triggered sweep oscilloscope is necessary to bring up a bare board. If after receipt of a bare board you feel that it is beyond your skill level, it may be returned (postpaid) for full credit toward purchase of the assembled and tested version. We offer bare boards as a service for those who cannot afford the assembled and tested units and are capable of performing their own purchasing, assembly, and debug.

DELIVERY

All products are normally available off-the-shelf for one week delivery. Occasionally we may be out of stock on a particular item in which case notification will be sent if delivery is expected to exceed 30 days. The severe shortage of 74LSXX integrated circuits now being experienced by everyone in the industry has caused us problems in obtaining parts.

WARNING

DO NOT PLUG OR UNPLUG *ANY* COMPUTER BOARDS WITH POWER ON. ALWAYS MAKE SURE THAT BOARDS ARE PLUGGED IN SECURELY PRIOR TO TURNING ON THE POWER TO THE SYSTEM. FAILURE TO DO SO WILL USUALLY BLOW CIRCUITS ON THE BOARD.

THE MTU SYSTEM PHILOSOPHY

As will be apparent while scanning through this catalog, the business of Micro Technology Unlimited is to provide a broad line of accessories for the most popular computers based on the 6502 microprocessor. The astute reader however should also notice that we can provide everything necessary to make an AIM-65, KIM-1, or SYM-1 into a uniquely powerful system in its own right. Thus although we do not currently sell the computer board itself, we do sell everything necessary to make that board into a complete system.

One may ask then, "What is MTU's design and system philosophy"? The list below should provide some insight into this.

1. KIM BUS compatibility. For design purposes the KIM bus is defined as the signals and pin assignments found on the expansion connector of KIM, SYM, and AIM computer boards. It is also defined to operate at a 1mHz cycle rate with uniform timing from cycle to cycle. Because of noise considerations we feel that bus buffers should be on the accessory boards, not the mother board, and we design that way.
2. Low power consumption. This is a prime consideration that is realized by the extensive use of low power shottky logic and dynamic RAM IC's for memory functions. Our boards typically use less than 1/4 the power of competitor's products. Low power operation not only means a smaller power supply, but also considerably less heat buildup in the system to affect reliability.
3. On-board regulation. All of our KIM bus accessory boards require only two unregulated voltages; +7 to +12 volts for the logic and +14 to +20 for memory IC's. Negative or high positive voltages, if required by the circuitry, are generated on-board. Local regulation significantly reduces system noise and insures accurate operating voltages for the circuitry. The low power consumption minimizes heat dissipation in the regulators as well.
4. Sensible packaging. While we do not provide dress covers for the system, we are sensitive to packaging considerations. All bus interface boards will fit into our K-1005 series of motherboard/card files giving a sturdy and compact if not beautiful system.
5. Software products are written using structured programming discipline. This not only simplifies the design and development task, it also eases understanding and modification by our customers.

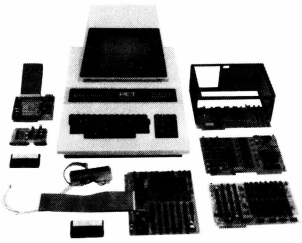
We also excel in the areas of production, quality control, and product test. Most production is done by our own people in our own plant. That which is done outside is restricted to the initial assembly of the simpler products with final assembly being done in-house. Engineering is directly involved in the initial production of new products and individually tests each unit in the first run. Succeeding production testing is often automated using the same computers our products support. For example, all boards containing memory devices are actually run in a system error-free (not just clocked on a burn-in rack) for 24 hours before being shipped. For this we use an AIM-65 and its printer to log test results. Power supplies are automatically tested at low line, high line, no load, and full load along with a maximum stress burnin to insure they function satisfactorily before shipment.

PET-2001 AND CBM USE PRODUCTS

The following products require no modification to function on the OLD 2001 and NEW 16/32K CBM microcomputers from COMMODORE.

PRODUCT NUMBER	DESCRIPTION	MORE INFO ON PAGE
K-1002-2	8 BIT DAC MUSIC BOARD FOR FREQUENCY/MUSIC GENERATION	19
K-1002-3C	PET 4 VOICE MUSIC SOFTWARE CASSETTE & USER MANUAL	20
K-1002-3L	PET 4 VOICE MUSIC SOFTWARE LISTING	20
NEW K-1002-6C	PET 4 VOICE INSTRUMENT SYNTHESIS MUSIC SOFTWARE	12
NEW K-1002-6DEMO	PET 4 VOICE INSTRUMENT SYNTHESIS AUDIO CASSETTE	12
K-1005-P	PET 5 SLOT CARD FILE FOR EXPANSION BOARDS	23
K-1005-3	BUS MOTHERBOAD	21
K-1005-4	APPLICATION MOTHERBOARD FOR CUSTOM CONNECTIONS	22
NEW K-1005-5	PET 2001 BRACKETS FOR K-1008-6 INTERNAL MOUNTING	22
NEW K-1005-6	PET 16/32K BRACKETS FOR K-1008-6 INTERNAL MOUNTING	22
K-1007-1	PET TO MTU BUS INTERFACE	24
NEW K-1007-2	PET 2001 CONNECTOR BOARD	25
NEW K-1007-3	PET 16/32K CONNECTOR BOARD	25
K-1008-P	VISIBLE MEMORY GRAPHICS DISPLAY/8K RAM BOARD	26
K-1008-3C	ASSEMBLY LANGUAGE GRAPHIC/TEXT S/W WITH BASIC CALLS	28
NEW K-1008-6	PET GRAPHIC INTERFACE BOARD	11
K-1012	SYSTEM EXPANSION BOARD WITH PROM, I/O, PROGRAMMER	30
K-1012-1	SUPER LOW POWER PROM ONLY BOARD	30
NEW K-1013-1M	APEX 65 DOS USER MANUAL	10
TBA K-1013-4D	PET FLOPPY DISK PACKAGE	10
K-1016	16K SUPER LOW POWER RAM MEMORY BOARD	31
K-1020	PROTOTYPING BOARD WITH VOLTAGE REGULATORS AND MANUAL	32

PET-2001 SUPPORT

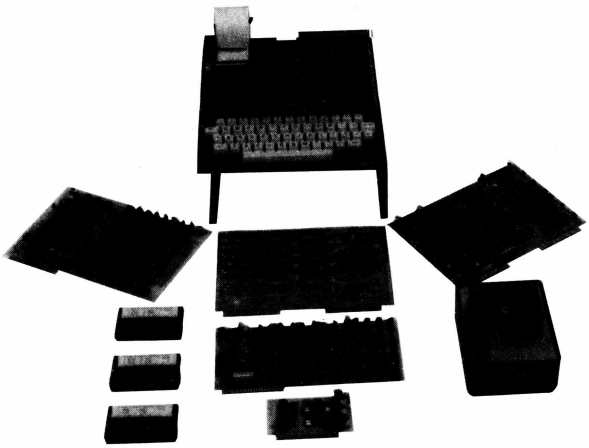


CBM SUPPORT

AIM-65 USE PRODUCTS

The following products require no modification to function on the AIM-65 microcomputer from ROCKWELL

PRODUCT NUMBER	DESCRIPTION	MORE INFO ON PAGE
K-1000-5	AIM-65 POWER SUPPLY FOR EDUCATIONAL/TABLE TOP USE	14
K-1002	8 BIT DAC MUSIC BOARD FOR FREQUENCY/MUSIC GENERATION	19
NEW K-1002-5C	AIM 4 VOICE MUSIC SOFTWARE	20
NEW K-1002-8C	AIM 4 VOICE INSTRUMENT SYNTHESIS SOFTWARE	12
K-1005-A	AIM 5 SLOT CARD FILE FOR EXPANSION BOARDS	23
K-1005-3	BUS MOTHERBOARD	21
K-1005-4	APPLICATION MOTHERBOARD FOR CUSTOM CONNECTIONS	22
K-1008	VISIBLE MEMORY GRAPHICS DISPLAY/8K RAM BOARD	26
K-1008-5C	GRAPHIC/TEXT SOFTWARE INTERFACED TO AIM BASIC	28
NEW K-1009-1C	GRAPHIC PRINT ROUTINE FOR AIM-65 PRINTER	13
K-1012	SYSTEM EXPANSION BOARD WITH PROM, I/O, PROGRAMMER	30
K-1012-1	SUPER LOW POWER PROM ONLY BOARD	30
NEW K-1013-1M	APEX 65 DOS USER MANUAL	10
NEW K-1013-3D	FLOPPY DISK CONTROLLER AND APEX 65 FOR AIM	10
K-1016	16K SUPER LOW POWER RAM MEMORY BOARD	31
K-1020	PROTOTYPING BOARD WITH VOLTAGE REGULATORS AND MANUAL	32



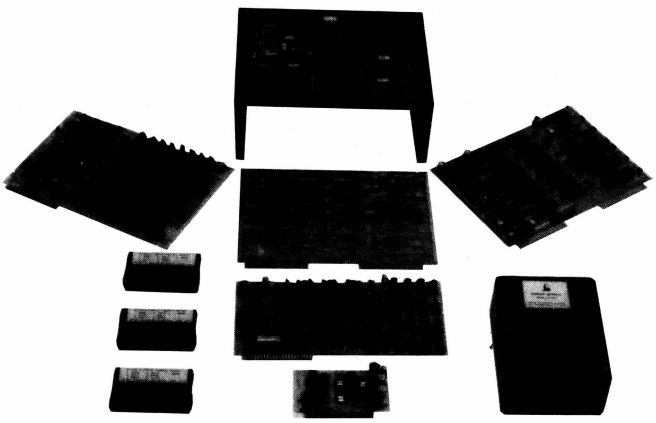
AIM ASSEMBLY

KIM-1 AND SYM-1 USE PRODUCTS

The following products require no modification to function on the KIM-1 microcomputer from COMMODORE.

PRODUCT NUMBER	DESCRIPTION	MORE INFO ON PAGE
K-1000	KIM-1 POWER SUPPLY FOR EDUCATIONAL/TABLE TOP USE	14
K-1002	8 BIT DAC MUSIC BOARD FOR FREQUENCY/MUSIC GENERATION	19
K-1002-1C	4 VOICE MUSIC SOFTWARE FOR THE KIM-1	20
NEW K-1002-7C	4 VOICE INSTRUMENT SYNTHESIS SOFTWARE DRIVER	12
K-1005-K	5 SLOT CARD FILE FOR KIM-1 AND 4 EXPANSION BOARDS	23
K-1005-3	BUS MOTHERBOARD	21
K-1005-4	APPLICATION MOTHERBOARD FOR CUSTOM CONNECTIONS	22
K-1008	VISIBLE MEMORY GRAPHICS DISPLAY/8K RAM BOARD	26
NEW K-1008-7C	GRAPHIC/TEXT & BASIC INTERFACE SOFTWARE	29
K-1012	SYSTEM EXPANSION BOARD WITH PROM, I/O, PROGRAMMER	30
K-1012-1	SUPER LOW POWER PROM ONLY BOARD	30
NEW K-1013-1M	APEX 65 DOS USER MANUAL	10
NEW K-1013-2D	FLOPPY DISK CONTROLLER AND APEX 65 FOR KIM	10
K-1016	16K SUPER LOW POWER AM MEMORY BOARD	31
K-1020	PROTOTYPING BOARD WITH VOLTAGE REGULATORS AND MANUAL	32

FOR SYM-1 OPERATING SOFTWARE, CONTACT:
LUX ASSOCIATES, CHICO, CA.



KIM ASSEMBLY

NEW PRODUCTS

K-1013 DISK CONTROLLER

(Page 7)

This is the definitive answer for high speed, high capacity floppy disk storage on AIM-65, KIM-1, and SYM-1 based systems. Double density and double sided operation on 8 inch disk drives is standard and up to 4 drives are supported. The board also has 16K of read/write memory and 256 bytes of permanent PROM for instant, automatic startup. Data transfers are via direct memory access to the on-board memory.

K-1013-1 APEX 65™ DISK OPERATING SYSTEM

(Page 8)

This powerful software package was custom designed for our K-1013 disk controller. It normally resides in 8K of the 16K of memory present on the disk controller board. Unlike other floppy disk systems, high operating speed was emphasized in the design of our DOS. Powerful user commands, system calls, and even a built-in math package maximizes the utility of the disk. Disk allocation is handled such that file sizes do not need to be known in advance and garbage collection is never required. An overlay facility allows detailed error messages to be used without tying up valuable system memory. Many of the system features are UNIX-like in their implementation.

K-1008-6 INTEGRATED VISIBLE MEMORY FOR THE PET

(Page 11)

This is the perfect graphic system board for the new style PET's as well as the original ones. The K-1007 bus interface and K-1008 Visible Memory have been combined onto a single board along with 5 ROM sockets, a light pen interface, and video overlay circuitry which allows simultaneous PET video and Visible Memory video to show on the screen. Unique bank switching circuitry allows all of the board resources to be used even if a fully loaded PET is being used.

K-1002-5 INSTRUMENT SYNTHESIS MUSIC SOFTWARE FOR PET

(Page 12)

This software package and one of our K-1002 series of 8 Bit Audio Digital-to-Analog converters can produce 4 simultaneous musical voices where *each harmonic of a voice has its own amplitude envelope*! This allows realistic synthesis of existing musical instruments as well as the ability to define new instrument sounds. This is the system written up in the April issue of Byte magazine.

NEW PRODUCT

K-1013 FLOPPY DISK CONTROLLER

The world has been waiting for it and now we have it! This is **THE** definitive answer to the floppy disk storage needs of KIM, SYM, AIM and PET microcomputers. This board has all of the features that exist for a disk controller including standard or mini-floppy operation, double density, double sided, up to 4 drives with simultaneous seek, 16K of on-board memory, initial program load ROM for turn-key systems, and of course complete KIM/SYM/AIM bus compatibility in the MTU tradition. The controller price includes a diskette with APEX 65, our powerful disk operating system (specify which machine you have).

The K-1013 Disk Controller was designed from the ground up for speed and reliability in data transfer operations. Disk data transfers are done via direct memory access to the on-board memory without program intervention. The simultaneous seek capability greatly speeds up disk intensive software. With specialized programs, one can actually sustain an average data transfer rate of over 40K bytes per second (20K for standard density) for an indefinite period with two standard 8 inch disk drives. Even using the generalized routines in the disk operating system, a 32K program can be located and loaded in less than 3 seconds (4 seconds standard density). The board uses a phase locked loop data separator which allows double density recording without loss of data accuracy.

The 16K of on-board read/write memory is split into two 8K blocks which can be independently addressed on any 4K boundary. One block is completely unrestricted in its use and is available for user program storage, data, etc. The other 8K block can be write protected (under software control) and is normally used to hold the disk operating system software and disk data buffers. Only 7.75K is actually RAM; the remainder is shadowed by the 256 byte IPL ROM and I/O addresses for the controller chip. Memory refresh and direct memory access cycles are totally transparent to the 6502 microprocessor and do **not** cause wait states.

SPECIFICATIONS

POWER REQUIREMENT: + 8 volts unregulated 600MA, + 16 volts unregulated 125MA.

BUFFERING: Maximum of 1 LS TTL load on address and data bus.

LSI CHIPS USED uPD765 disk controller, 4116 dynamic RAM 200NS access time.

SYSTEM CLOCK FREQUENCY: Phase 2 clock frequency must be 1.0mHz crystal controlled as provided by all KIM, SYM, AIM, and PET computers.

DISK DRIVE INTERFACE: Shugart 8 inch SA801 or SA851 compatible drives may be used directly. Others including all 5¼" drives require cabling change and possibly slight K-1013 modifications.

PHYSICAL: 7½' high by 11" wide exclusive of edge fingers; fits the K-1005 series of card files.

INCLUSIONS: Assembled and tested board, hardware manual containing installation instructions, principles of operation, schematic, and a diskette (8") with disk diagnostic program and APEX 65.

NOT INCLUDED: Disk drives, disk drive power supply, cable from controller to disk. (Uses 50 pin ribbon cable with normal ribbon cable connector on one end and 50 pin edge connector on the other end)

NEW PRODUCT

APEX 65[tm] DISK OPERATING SYSTEM

With the introduction of APEX 65 (**A**pplications **P**rogram **EX**-ecutive), MTU proves that microcomputer software has finally come of age by providing the reliability, flexibility, and efficiency which has been long sought after but not found on small systems until now. Unlike other DOS systems which are patched and "adapted" to their hardware environment, APEX 65 was engineered from the ground up for integration with the MTU K-1013 Disk Controller board. The on-board ROM brings up all of APEX 65 (including system tables and disk buffers) in 8K of on-board write-protected RAM providing insurance against system "crashes" when errant user programs inadvertantly write into system memory.

APEX 65 provides the user with **true** device-independent I/O over logical "channels", as found on large expensive mainframe computers. A program can output to a printer, display, or disk file with equal ease. Since I/O channels can be assigned by simple monitor commands, programs can access different devices or files without any modification. Disk I/O is completely transparent to application programs which do not need buffers, "File Control Blocks", or other artifaces in order to perform disk I/O. True random access is supported since only one disk access is needed to reach any record in a file.

Files are named with up to 12 characters plus a single character extension, and are virtually free of restrictions. Files are limited in size only by the remaining disk space, otherwise they may be up to 16 Megabytes long. Files may be updated in place and appended to at any time. Reads and writes can be freely mixed using variable length records from 1 to 65,535 bytes each. I/O can be performed concurrently on several files, multiple channels can be assigned to the same file, and files can be individually write-protected. Maximum file sizes need not be known in advance and no garbage collection is ever required.

The APEX 65 built-in monitor provides over 24 built-in, free-format commands which can be extended to include an almost unlimited number of user-defined commands. English-language diagnostic messages help pinpoint user errors easily. Monitor commands may also be read from files in order to provide a Batch capability. A Batch job can even be initiated automatically on power-up for turn-key applications.

Interfacing to application programs is a snap using APEX 65's address independent "Supervisor Call" instruction which can activate any of dozens of I/O and utility functions including little niceties such as 16 bit multiply and divide. The supervisor call function utilizes the 6502 BRK instruction which is followed by the arguments, if any. Since APEX 65 uses no interrupts or critically timed loops, applications programs can fully utilize interrupts — even during disk accesses!

Efficiency has not been sacrificed for versatility either; APEX 65 can search the disk directory, locate, load, and execute a 32K byte program in less than 3 seconds. Most important, there is that all-important MTU reliability, committment to continuing support, and detailed documentation which will quickly enable you to focus the power of APEX 65 on **your** application.

SPECIFICATIONS

DISK DRIVE TYPE:	8 inch Shugart compatable 1 or 2 sided, 1-4 drives
DATA RECORDING TECHNIQUE:	MFM Double Density (for single density, contact MTU)
SECTORING:	IBM compatible soft sectoring, 77 tracks, 26 sectors, 256 bytes/sector
INTERLEAVING:	APEX 65 disks are formatted for alternate sector numbering and a 6 sector rotation every track. This allows for continuous data transfer without loss of a disk revolution when stepping to the next track.
STORAGE CAPACITY:	512K bytes per side, maximum 1M bytes/ disk, 4M bytes per system.
FILE SIZE:	500K bytes single-sided, 1M bytes double-sided.
NUMBER OF FILES:	248 maximum per disk.
NUMBER OF OPEN FILES:	4 is standard; 6 is possible with buffers in the user half of disk controller RAM.
SPACE ALLOCATION METHOD:	Linked-list by disk blocks. The links are kept in the directory, not the file itself.
DISK BLOCK SIZE:	2048 bytes single-sided, 4096 bytes double-sided.
SYSTEM OVERHEAD:	Track 12 is used for the directory.
RELIABILITY FEATURES:	Directory information and the block allocation table is redundantly recorded and a directory rebuild program is included. DOS memory is write protected after DOS is loaded.
MEMORY REQUIREMENTS:	8K of RAM on the disk controller, 65 bytes of page 0.
COMMAND SYNTAX:	Free format commands with parameters specified by position; default parameters provided. Command verbs may be abbreviated (e.g. "ASSIGN" is equivalent to "AS."). Syntax prompts are available.
NUMERIC PARAMETERS:	May be HEX or DECIMAL or expressions formed with "+", "–", "*", "/" (integer), or "\" (remainder) operators.

PRELIMINARY LIST OF AVAILABLE USER COMMANDS:

ASSIGN	Associate I/O channel with device or file.
FREE	Release previously assigned device or file.
BEGINOF	Position channel to logical beginning of file.
ENDOF	Position channel to logical end of file.
FILES	List all or selected file names, sizes, etc.
STATUS	Display channel assignments and remaining space.
SAVE	Save memory image on a file.
GET	Load memory image from a file.
ERASE	Remove file from disk.
RENAME	Change name of file.
GUARD	Protect file from write, erase, or rename.
UNGUARD	Remove guard status from file.
VERIFY	Compare memory to file.
LIST	Output file to selected device or file.
DUMP	Display memory or file in hex on selected device.
MEMORY	Set memory (bytes, words, hex, decimal, ASCII).
FILL	Fill memory block with constant (hex, decimal, ASCII).
COPY	Move memory block, any size, non-destructive.
REGISTER	Display or set registers (hex, decimal, ASCII).
GO	Execute program in memory.
CONTINUE	Continue execution after manual abort or breakpoint.
SEARCH	Search memory block for value or string.
COMPARE	Compare two memory blocks
PROTECT	Write protect system memory.
UNPROTECT	Un-protect system memory.

APEX 65 con't

PRELIMINARY LIST OF SUPERVISOR CALLS (SVC):

Input character or byte from channel
Output character or byte to channel
Input line, record, or string from channel
Output line, record, or string to channel
Execute monitor command from channel or memory
Execute list of monitor commands from channel
Input or decode hex ASCII string to value
Output or encode value to hex ASCII string
Input or decode decimal ASCII string to value
Output or encode value to decimal ASCII string
Query channel status
Define non-standard NMI or IRQ vectors
Define non-standard error recovery vectors
Load and execute
Modify system attribute
Roll-out DOS (i.e., free memory used by DOS)
Roll-in DOS (recover DOS memory image)
Specify default input channel
Specify default output channel
Output immediate (inline) message
Assign channel to device or file
Free channel
Load file
Save file
Position file or device
Display memory
Display registers
Search for string
Fill memory block with constant
Copy memory block
Compare strings
Abort to monitor
Return to monitor
Fold lowercase alpha to uppercase

16 BIT ARITHMETIC PSEUDO-PROCESSOR: A built in 16 bit pseudo processor provides users with a convenient method of communicating 16 bit parameters to DOS during program execution and for performing 16 bit arithmetic. A set of 7 pseudo-registers is provided in page 0 with the following operations supported:

Double precision complement	Double precision remainder
Double precision add	Double precision load
Double precision subtract	Double precision move
Double precision multiply	Double precision store
Double precision divide	Double precision compare

KIM-1 VERSION OF APEX 65: K-1013-2D

Supplied on a double density single-sided diskette assembled at E000 and C000. The KIM monitor is not used and by a simple jumper change, Reset will go to DOS rather than the KIM monitor.

AIM-65 VERSION OF APEX: K-1013-3D

Supplied on a double density single-sided diskette assembled at 6000 and 8000. Interface to AIM-65 BASIC is restricted to program load and save and I/O through the User channel of the AIM monitor. Interface to AIM assembler is restricted to I/O through the User channel of the AIM monitor.

SYM-1 VERSION OF APEX: K-1013-5D

Supplied on a double density single-sided diskette assembled at 6000.

APEX 65 USER'S MANUAL: K-1013-1M

Complete description of commands on both a beginner's level and a system programmer's level. Supplied looseleaf in a three-ring binder for easy updating. Source listings of DOS are not available. Contact MTU for licensing agreements for use of APEX 65 in products or systems.

NEW PRODUCT

K-1008-6 INTEGRATED VISIBLE MEMORY FOR THE PET

This board is the newest member of our series of high resolution graphics products for PET and CBM computers. Basically it is a combination of our K-1007-1 PET to KIM bus interface board and our K-1008 Visible Memory. However since everything is on a single board, it will fit **inside** the computer's cabinet for maximum protection and portability. By ordering the correct plug assembly (K-1007-2 for old style PET's or K-1007-3 for the new style PET or CBM), this board works equally well with either style of PET.

However we have done much more than meld the previous circuitry together. The K-1008-6 has a video mixing capability which allows PET video, Visible Memory video, or **both** to appear on the screen at any time under software control. The board also contains five ROM sockets for holding ROM based software such as Commodore's word processor, the MacroTea, Programmer's Toolkit, and others all at the same time. It even has provisions for a light pen register which latches the X and Y screen position when triggered by an external logic signal. Even with all of this it still generates a KIM bus at its edge fingers for simple interfacing to all of our KIM/SYM/AIM bus interface boards including our K-1013 disk controller.

We have taken a unique approach to solving the address space saturation problem that occurs when expanding PET's that already have 32K of memory. The multiple board functions are actually divided into eight "devices" which are Visible Memory upper 4K, Visible Memory lower 4K, each of 5 ROM sockets, and the external KIM bus. Each of these devices may be independently addressed on 4K boundaries by means of jumpers. A separate software controlled Enable Register determines which "devices" are active at a particular time. By enabling devices only when needed, it is possible to have more than one assigned to the **same** 4K block. This is particularly beneficial when using the ROM sockets because ROM's from different sources that must reside in the same address block can be in the system simultaneously. There is even a jumper selectable default enable configuration that restores the system to a "standard" configuration after power up or reset activation.

When using the KIM expansion bus capability, the board should be plugged into a K-1005-P card file. The on-board power supply, which is driven by AC and unregulated DC from the PET's transformer, has sufficient power to drive several MTU standard bus interface boards.

SPECIFICATIONS

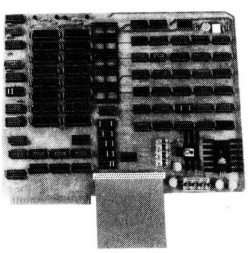
DIMENSIONS — 11″ wide by 8.5″ deep by 1″ thick exculsive of edge fingers (and mounting bracket).

RAM TYPE — uPD411 22 pin 4K dynamic RAM or equivalent.

ROM TYPE — 4K byte masked ROM as used in the newer PET's, 2332 pinout.

LIGHT PEN INPUT — Active-low schmidt trigger with 27K pullup to +5.

SOCKETING — All integrated circuits are socketed.



INCLUSIONS — Assembled and tested board, connecting cable, user's manual containing use instructions, technical description, schematic, and diagnostic program listing.

NOT INCLUDED — Mounting brackets for internal mounting, connector board, light pen register IC's. See K-1005-4 listing for mounting bracket description.

MICRO TECHNOLOGY UNLIMITED
MARCH 1, 1980 PRICE LIST

	PRICE	PRODUCT	DESCRIPTION
	39.00	K-1000	KIM-1 POWER SUPPLY
#	65.00	K-1000-5	AIM-65 POWER SUPPLY
#	49.00	K-1002	8 BIT DAC BOARD
	6.00	K-1002M	8 BIT DAC MANUAL ONLY
	20.00	K-1002B	8 BIT DAC BARE BOARD
	20.00	K-1002-1C	KIM ADV. MUSIC S/W CASSETTE W/SOURCE
#	59.00	K-1002-2	PET 8 BIT DAC BOARD
	10.00	K-1002-2M	K-1002-2 MANUAL ONLY
	23.00	K-1002-2B	PET 8 BIT DAC BARE BOARD
	20.00	K-1002-3C	PET ADVANCED MUSIC S/W CASSETTE
	15.00	K-1002-3L	PET ADVANCED MUSIC S/W LISTING ONLY
	20.00*	K-1002-5C	AIM-65 ADVANCED MUSIC S/W CASSETTE
#	49.00**	K-1002-6C	PET INSTRUMENT SYNTHESIS MUSIC S/W
#	49.00**	K-1002-7C	KIM INSTRUMENT SYNTHESIS MUSIC S/W
#	49.00**	K-1002-8C	AIM INSTRUMENT SYNTHESIS MUSIC S/W
#	5.00*	K-1002-6DEMO	INSTRUMENT SYNTHESIS DEMO CASSETTE
#	5.00	K-1005M	CARD FILE MANUAL ONLY
#	85.00	K-1005-A	AIM-65 CARD FILE
	75.00	K-1005-K	KIM CARD FILE
	75.00	K-1005-P	ALL PET CARD FILE
#	75.00	K-1005-S	SYM CARD FILE
	38.00	K-1005-3	CARD FILE BUS MOTHERBOARD
	12.50	K-1005-3B	K-1005-3 BARE BOARD
	29.00	K-1005-4	CARD FILE APPLICATION MOTHERBOARD
	8.00	K-1005-4B	K-1005-4 BARE BOARD
#	10.00**	K-1005-5	BRACKETS FOR K-1008-6 IN 16/32K PET
#	15.00**	K-1005-6	BRACKETS FOR K-1008-6 IN 2001 PET
	10.00	K-1007-1M	K-1007-1, 2, 3 MANUAL ONLY
#	78.00	K-1007-1	PET TO MTU BUS INTERFACE
#	35.00	K-1007-2	"OLD" PET-2001 CONNECTOR BOARD
#	59.00	K-1007-3	"NEW" 16/32K PET CONNECTOR BOARD
	240.00	K-1008	8K RAM VISIBLE MEMORY BOARD
	42.00	K-1008B	VISIBLE MEMORY BARE BOARD
	10.00	K-1008M	K-1008 MANUAL ONLY
	243.00	K-1008-P	PET VISIBLE MEMORY VERSION
	20.00	K-1008-3C	ALL PET GRAPHIC/TEXT S/W CASSETTE
	25.00	K-1008-5C	AIM-65 GRAPHIC/TEXT S/W CASSETTE
#	40.00	K-1008-5CS	K-1008-5 SOURCE CASS. W/LISTING
#	320.00*	K-1008-6	PET GRAPHIC INTERFACE BOARD
	10.00*	K-1008-6M	K-1008-6 MANUAL ONLY
#	27.00	K-1008-7C	KIM GRAPHIC/TEXT S/W CASSETTE
	25.00	K-1009-1C	AIM-65 GRAPHIC PRINT S/W CASSETTE
	295.00	K-1012	PROM-I/O BOARD
	165.00	K-1012-1	PROM ONLY BOARD
	60.00	K-1012B	PROM-I/O BARE BOARD
	10.00	K-1012M	PROM-I/O MANUAL
	10.00**	K-1013M	FLOPPY DISK CONTROLLER MANUAL
	25.00**	K-1013-1M	APEX 65 USER MANUAL
	595.00**	K-1013-2D	KIM FLOPPY DISK PACKAGE
	595.00**	K-1013-3D	AIM-65 FLOPPY DISK PACKAGE
	595.00**	K-1013-4D	PET FLOPPY DISK PACKAGE
	595.00**	K-1013-5D	SYM FLOPPY DISK PACKAGE
#	298.00	K-1016	16K MEMORY BOARD
	60.00	K-1016B	16K MEMORY BARE BOARD
	10.00	K-1016M	K-1016 MANUAL ONLY
	42.00	K-1020	PROTOTYPING BOARD

\# NEW PRODUCTS OR PRICE CHANGE
* AVAILABLE APRIL 30, 1980 ACCEPTING ORDERS NOW
** AVAILABLE MAY 30, 1980 ACCEPTING ORDERS NOW
ALL OTHERS NOW AVAILABLE

NOTES:

1. S/W MEANS SOFTWARE
2. ALL BOARDS (ASSEMBLED OR BARE) COME SUPPLIED WITH MANUALS. IF MANUAL HAS BEEN PURCHASED SEPARATELY EARLIER, REDUCE THE BOARD PURCHASE PRICE BY THE MANUAL PRICE (NOT INCLUDING SHIPPING)
3. ALL SOFTWARE CASSETTES COME WITH A USER MANUAL
4. BARE BOARDS AVAILABLE IN U.S. ONLY.

ORDER FORM

NAME/COMPANY _____

SHIPPING ADDRESS: _____

CITY: _____ STATE: _____ ZIP: _____

BUYER: _____ PHONE: _____ PURCHASE ORDER #: _____

QUANTITY	MTU PART NUMBER	DESCRIPTION OF PART	PRICE EACH	PRICE TOTAL
		COLUMN TOTAL		
		SHIPPING & HANDLING (INTERNATIONAL OR UPS BLUE)		

Please include payment with order, if not, shipment will be made COD.
TERMS AVAILABLE TO QUALIFIED INSTITUTIONS.

MTU APPLICATION NOTES

AN-1 Battery Power for the KIM-1. Describes how the K-1000 power supply in conjunction with a standard 12 volt storage battery can power a KIM-1.

AN-2 Using the Visible Memory for Grey Scale and Color. Describes how two or more Visible Memory boards may be synchronized together and their outputs combined to provide a grey scale or color video display with full resolution.

AN-3 Operation of the Visible Memory on 50Hz Power. Describes several ways to successfully operate the Visible Memory in areas where primary power is 50Hz.

AN-4 Additional Notes on the K-1012 PROM/IO Board. Describes how to program and use the new 5 volt EPROMS (2508, 2516, 2732, and Intel 2716) on the K-1012.

AN-5 Addressing the Visible Memory on Odd 4K Boundaries. Modifications to the Visible memory for addressing at 1000, 3000, etc. for use on the AIM-65.

AN-6 Addressing Considerations in AIM-65 Systems. Discusses the many options available in assigning addresses in an expanded AIM-65 system. Also describes a method for freeing up half of block A000 for expanded I/O.

BUILDING A SYSTEM FROM MTU COMPONENTS

Below is listed an example system that can be built using an AIM-65 based computer and MTU accessory boards. Similar systems may be constructed around the KIM-1 and SYM-1 microcomputers. The actual configuration of course depends on the application. For those on limited budgets the order of listing reflects the recommended order of purchase for maximum capability early in the expansion cycle.

FIRST:

AIM-65 MICROCOMPUTER (MTU does not supply this)

K-1000-5 POWER SUPPLY. This will power the entire system listed below.

SECOND:

K-1005-A CARD FILE. This will support and protect the AIM while holding the expansion boards.

K-1008 VISIBLE MEMORY. This can be used as a 22 line by 53 character text display, 320 by 200 graphic display, or an 8K memory expansion.

VIDEO MONITOR. (MTU does not supply this)

BASIC ROM SET (IF DESIRED) (MTU Does not supply these)

SIX 2114 RAM IC'S to expand AIM's on board memory to 4K (MTU does not supply these)

K-1008-5C GRAPHIC/TEXT SOFTWARE. This will interface the AIM monitor to the Visible Memory display for easier use of the editor and BASIC as well as provide a library of graphics subroutines for use from BASIC or machine language.

K-1009-1 GRAPHIC/TEXT PRINT SOFTWARE. This will allow hard copy of the Visible Memory display to be printed on the AIM printer.

FOURTH:

K-1013-2D DISK CONTROLLER. Provides an additional 16K of memory (8K used by DOS) The APEX 65 software contains all of the programming necessary for machine language programs to effectively use the disk.

DISK DRIVES(S) Shugart SA801 or equivalent .

POWER SUPPLY FOR DISK DRIVE (MTU does not supply this)

FIFTH:

K-1016 16K MEMORY. This will provide considerably more memory for BASIC and machine language programs to use.

K-1012 PROM/IO BOARD. This should be used for I/O intensive applications where immediate power-up and go operation is necessary. Ideal for automated test equipment applications.

K-1002 DIGITAL TO ANALOG HARDWARE

Give your microcomputer a singing voice, in fact, give it 4 voices! The K-1002 music boards are complete audio output systems for microcomputers. They connect to any parallel I/O port for data and require 5 volts only to operate. With 6502 based systems, up to four quality musical tones may be generated simultaneously. Tones are generated using a sampling technique with waveform tables stored in memory.

In operation, a string of 8 bit bytes is sent to the 8 bit digital-to-analog converter section at a rate of 8KHz or greater. The converted output voltage is fed to a sharp cutoff low-pass filter to remove switching spikes and alias distortion thus generating a smooth waveform. The filtered output is then routed to a low power high-fidelty amplifier capable of driving any 4, 8, or 16 ohm speaker.

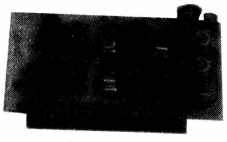
These systems are capable of audio quality that far surpasses other software based microcomputer music systems. A wide variety of tone colors may be generated by changing waveform tables. Even dynamic waveform changes and amplitude envelopes are possible by rapidly switching among a number of tables. Although software is the key to this level of performance, a microcomputer with 4K of memory available is sufficient to realize virtually the full potential of the technique.

This technique of sound generation offers the user maximum flexibility and upward mobility. MTU will be announcing digitized speech and analysis software which will use these boards for playback. Thus, showing that not only can music be generated, but other desired sounds.

The power requirement is regulated +5 volts @ 30MA peak driving an 8 ohm speaker. The Digital-to-Analog section is 8 bits guarenteed monotonic with straight binary input code, 0 to +5 volts output, 5K source impedance, and uses the 5 volt power supply as a reference after heavy filtering. The lowpass filter section has 6 poles with a 0.5dB Chebyshev response, 3.5kHz cutoff frequency and unity gain. The amplifier section has a 20Hz to 20KHz response ±3dB, can drive a load impedance of 4 ohms or more with a power output of 250MW at 8 ohms. The amplifier includes an onboard volume control.

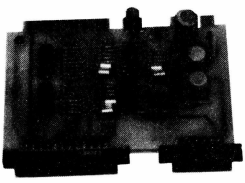
MANUALS: Complete hardware schematic, parts list, layout, and an article reprint describing the theory of operation and containing a listing of a 4 part harmony music program. Purchase of the K-1002 series music software packages is recommended for ease of use and full realization of the capabilities of the board.

STANDARD HARDWARE BOARD:
K-1002
PHYSICAL SIZE: 3" deep by 5.5" wide with 22 position edge fingers (contact spacing of 0.156") on the 5.5" dimension. The board fits into the K-1005 card files instead of seperate mounting outside.



K-1002

VERSION FOR THE 2001 AND 16/32K PETS: K-1002-2
The board is 4.0" Wide by 5.0" Long and includes 2 edge connectors which plug onto the user port and second cassette port (for power) on the rear of the PET. All signals from both ports are fed throught the board to a set of edge fingers on the opposite side making them available for other uses. As a service, the CB2 signal used by many PET games is also routed to the audio amplifier allowing its continued use with the DAC amplifier and speaker. A phono jack for connection to a speaker is also provided.



K-1002-2

FOUR-VOICE MUSIC SOFTWARE

The following software packages are based on the original DAC method of producing multi-part music described in an article by Hal Chamberlin in the 9/77 issue of Byte. The musical tones produced have a limitless variety of different waveforms but the rectangular envelopes tend to give an organ-like timbre. The primary advantages of these packages are simplicity of use and memory requirements as small as 1K.

FOUR VOICE MUSIC SOFTWARE FOR KIM-1: K-1002-1C

This package is a collection of several programs designed to enhance the educational and musical value of the KIM-1 processor and the K-1002 music board.

The SIMPLIFIED MUSIC INTERPRETER allows the user to code and play song tables. It is essentially the same as the one described in the Byte Magazine article. Musical "subroutine" (refrains) capability has been added with nesting to over 10 levels depending on stack allocation. This program runs in the basic KIM-1 memory.

The NOTRAN MUSIC COMPILER accepts an ASCII string from the teletype serial port (or other device with user supplied I/O routines) and produces interpretive code in memory for the advanced music interpreter. The compiler requires 2.5K of memory plus storage for interpretive song data.

The ADVANCED MUSIC INTERPRETER allows a more compact and flexible song table than the simplified interpreter while retaining 4 voice capability. Each musical event requires as little as 1 byte rather than the constant 5 bytes needed by the simplified interpreter. Provisions for separate waveforms for each voice, variations in tempo, changes in timbre, and "musical subroutines" are included. The interpreter resides in 1K memory with an additional 4K recommended for song and waveform storage. It accepts song table code generated by the NORTRAN COMPILER or by hand.

The FOURIER SERIES PROGRAM accepts a table of up to 16 harmonic amplitudes and phases generated by the user. It computes a 256 point waveform table usable with either the simplified music interpreter or the advanced interpreter. This allows new waveform tables (i.e. timbres) to be generated by the user. This program runs in the basic KIM-1 memory.

The software package comes supplied on KIM-1 readable cassette stored in KIM and HYPERTAPE format and includes a user manual. It requres a KIM-1, K-1000 power supply, cassette recorder (for loading only), speaker and K-1002 board to run. For the ADVANCED INTERPRETER, it is recommended that 4K bytes of RAM be available.

FOR SYM-1 VERSION CONTACT: LUX ASSOCIATES, Box 315, Chico CA 95927 916-895-8751

FOUR VOICE MUSIC SOFTWARE FOR ALL PETS: K-1002-3C

This software program generates 4 voices simultaneously and is designed to run on all Commodore PET computers. It is a completely rewritten version of the K-1002-1 KIM-1 music software package. It allows the user to compose and/or playback songs with up to four part harmony. Each part may have a different tone color (waveform) and a six octave (C_0 to C_6) range is possible. Many of the run-time features of the NOTRAN music compiler interpreter have been incorporated while maintaining compatibility with the original 5 byte per event song table format as proposed by Hal Chamberlin in BYTE magazine. A very powerful feature of the system utilies a separate SEQUENCING TABLE which is used to control dynamic tempo. create or change waveforms, change voice assignments and the number of active voices, perform repeats, and call refrains. A Fourier series routine allows new waveform tables to be computed on the fly during natural pauses in the music as short as a fraction of a second. The software is supplied on PET cassette with several encoded songs. The user's manual gives complete instructions for coding song and sequencing tables and includes coding form masters. The music interpreter will function in 8K bytes.

NOTE: This software package was written by Dr. Frank Covitz, and active PET user.

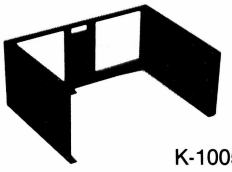
FOUR VOICE MUSIC SOFTWARE FOR AIM-65: K-1002-5C

This is essentially the same as the K-1002-1C version for the KIM-1 except it has been reassembled and made compatable with the AIM-65. It comes supplied on AIM-65 cassette with user manual.

CARD FILES AND MOTHERBOARD
K-1005 SERIES

The K-1005 card file system was designed to answer the need for a compact quality mechanical support and electrical connection system for the KIM BUS family of microcomputers. The system consists of a card file frame, custom processor board mounting brackets, and two types of connector backplanes.

FRAME: K-1005 for all versions



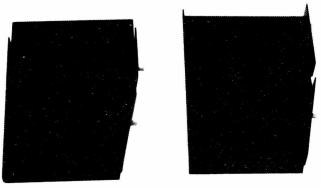
K-1005

The card file frame is "U" shaped and is constructed of black anodized aluminum with insulating plastic card guides for mechanical support of the cards. It holds up to five boards inside the frame. The bottom of the "U" has cutouts at the "Expansion" and "Application" positions of KIM, SYM and AIM processor boards. This allows mounting individual connectors or the K-1005 series of motherboards with connectors. The top and bottom edges of the frame are bent in for ½ inch and contain holes for mounting to adjacent surfaces. The frame mechanical dimensions are: 11.25 inches wide, 4.75 inches high, and 8.5 inches deep (less motherboard). The frame is designed for cards 11.0″ wide and any depth up to 8.5″. All direct bus interface cards listed in this catalog fit these dimensions.

BRACKETS: K-1005-2K for KIM/SYM/PET, K-1005-2A for AIM-65 (left & right as a set)

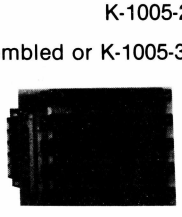
K-1005-2K

The KIM-1/SYM-1 bracket mount the processor in the top slot of the card file to allow access to the keyboard. The AIM-65 brackets extend the card file depth and mount the AIM-65 on top of the card file frame by plugging into a motherboard (mandatory) and screw mounting to the two brackets at the back. The AIM keyboard is mounted by the brackets at an 11.5 degree angle (standard typewriter keyboard angle) and is positioned in front of the AIM display, opposite the motherboard side. There are then 5 slots in the AIM card file with 4 serviced by the motherboard.



K-1005-2A

BUS MOTHERBOARD: K-1005-3 assembled or K-1005-3B bare



The bus motherboard is a double sided, plated through, glass epoxy printed circuit board. It is supplied assembled with five connectors which are parallel wired or it can be purchased bare for custom uses and modifications. The signals are bus connected on the "inside" and the outside is covered with ground plane copper to shunt noise. The topmost connector plugs onto the processor EXPANSION CONNECTOR fingers. This socket does not have lines running to all the pins (left out are: 2, 3, 16, 17, 18, 19, 20, X) because MTU boards use some of these pins for power, and the different processors use them for other functions not pertaining to bus operation. There is no buffering on the motherboard, thus, it draws no power. The short bus and proper attention to shielding and grounding allows the full 4 low power Schottky load capability of the processor-bus to be realized. A five screw terminal strip on the motherboard provides power connections to the processor (+5 and +12 volts regulated) and expansion boards (+7.5 and +16 volts unregulated). The board size is 3.8″ high by 5.1″ wide by 1.0″ deep. The connectors are 0.156 inch contact spacing, 44 pin double sided, gold contact surfaces.

CARD FILES con't

APPLICATION MOTHERBOARD: K-1005-4 assembled or K-1005-4 bare

K-1005-4

For a system to be flexible for most any desired task, it is necessary to allow customization. This coupled with the need to bring signals outside the computer "box" was the driving force for the development of this motherboard it fulfills these needs by providing a one piece mounting for 5 application edge connectors and four standard 24 pin dual in line interface sockets. The board uses printed circuit tab connectors and sockets for solder wiring of custom connections. With either version, the printed wiring is ground plane only, no wire interconnects. Thus, 5 boards can mate with the motherboard to interchange signals and 96 signals can be brought to the outside world. The edge of the board extends beyond the edge of the card file to allow room for the I/O cables to plug into the I/O sockets. The standard 24 pin DIP socket was chosen because of the easy availability of mating ribbon cables with 24 pin plugs.

BRACKETS FOR 16/32K PET MOUNTING: K-1005-5 (set of 2)

This bracket set (2 identical brackets) is used to mount a K-1008-6 Graphic Interface Board inside the 16/32K PET and CBM computers.

BRACKETS FOR 2001 PET MOUNTING: K-1005-6 (set of 2)

This bracket set (2 brackets + K-1005-6 set) includes the K-1005-6 bracket set and is used to mount a K-1008-6 Graphic Interface Board inside the 2001 PET computer. If upgrade is made to the 16/32K PET system, these brackets can be used with screwdriver modification only.

DISCUSSION OF EXPANDING THE 6502 SINGLE BOARD COMPUTERS

The KIM BUS systems come with "unbuffered" signals on their expansion connector. This means that the 6502 processor chip itself is the driver for the address and data lines. The clock and Write Enable control lines are driven by TTL gates. Large bus-oriented systems, such as S-100 systems, typically have powerful bus buffers on their processor board which are designed to drive dozens of peripheral boards. The peripheral boards in turn also have buffers to minimize loading of the large system bus. The large number of buffers and their strong, fast-risetime outputs are responsible for some of the power consumption and most of the noise seen in S-100 systems.

Most competing motherboards for 6502 single-board computers duplicate this philosophy by providing buffers for the processor on the motherboard itself. While this is indeed necessary for very large systems, it is **NOT** necessary when only a few expansion boards are to be added **and** the boards are designed with low-power shottky logic connecting to the bus. The 6502 processor is specified to be and is fully capable of driving 5 low-power shottky inputs and 25 MOS inputs such as memory and I/O chips or disabled tri-state driver outputs. One of these low-power shottky inputs and as many as 18 of the MOS inputs are present on the processor board itself leaving 4 low-power shottky in-puts and 7 disabled tri-state outputs for expansion. Thus there is enough drive capability left over for at least four expansion boards provided that each presents a maximum of one low-power shottky input and one tri-state output to either the address or the data bus.

CARD FILES con't

We feel that the advantages offered by our unbuffered motherboards far outweigh the single disadvantage of being limited to 4 expansion boards. In particular our motherboard is much smaller, less expensive, and more power conservative than others on the market. The small size allows it to be installed into a simple and compact card file that completely protects the expansion boards from "stray elbow" type accidents that can easily wipe out the entire system when the expansion boards are left exposed on the table. The simplicity of the unbuffered bus (simply 5 edge connectors wired together) also eases trouble-shooting of blown systems because the motherboard need not be suspected as the trouble source. Finally extensive groundplane shielding, the exceptionally short bus itself, and lack of powerful bus buffers contributes to a low system noise level; much lower than most buffered bus systems.

In order to determine how much operating margin can be expected with an unbuffered 6502 bus system, MTU built the AIM-65 system pictured at the bottom of this page. Using three of our K-1005 motherboard/card files wired together, we were able to plug 12 of our 16K memory boards into the bus and the system still worked admirably. The I/O ports on the AIM were used to selectively enable boards (through the A15 address line) so that a memory test could be executed on the 192K of memory installed. A check of address and data bus signals with an oscilloscope revealed somewhat liesurely rise and fall times but solid zero and one logic levels with plenty of timing margin remaining. Clearly there is adequate margin when the rated maximum of four expansion boards is used. (It is interesting to note that a single MTU K-1000-5 power supply powered the AIM, its printer, and all of these boards without excessive strain.)

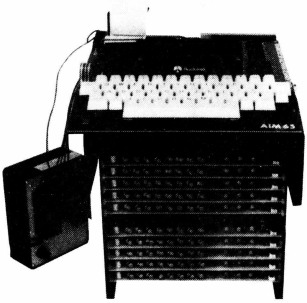
CARD FILE ASSEMBLIES

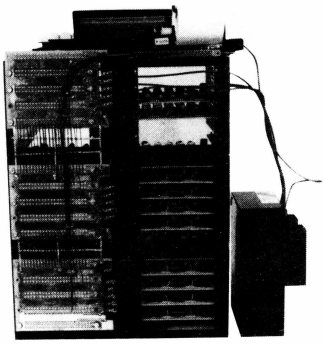
The following preassembled card files are available by ordering the associated number. They come with frame, processor bracket, mounting hardware, and bus motherboard.

NUMBER	FOR MICRO-COMPUTER	CONTAINS
K-1005-A	AIM-65	K-1005, K-1005-2A, K-1005-3, HARDWARE
K-1005-K	KIM-1	K-1005, K-1005-2K, K-1005-3, I/O CONNECTOR, HARDWARE
K-1005-P	ALL PETS	K-1005, K-1005-2K, K-1005-3, HARDWARE
K-1005-S	SYM-1	K-1005, K-1005-2K, K-1005-3, HARDWARE

DEMONSTRATION SYSTEM CONTAINS:

AIM-65
4K bytes of 2114 RAMs
AIM BASIC ROMs
AIM Monitor ROMs
AIM Assembler ROMs
3 K-1005 card files
12 K-1016 16K RAM boards
All powered by K-1000-5 supply!!!
And most important, NO BUS BUFFERS





PET INTERFACES TO MTU BUS

MTU has redesigned the K-1007 series of interfaces to allow working with all Commodore PET computers. The series presently contains 3 boards explained below.

SEE ALSO K-1008-6 PET GRAPHIC INTERFACE

PLEASE READ CAREFULLY — Two boards are needed to work with any PET. We regret having so many numbers to choose from, but there are many options which can be selected to allow the user maximum flexibility in expansion.

PET TO MTU INTERFACE BOARD: K-1007-1

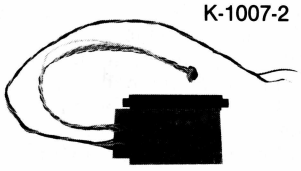
The K-1007-1 converts the PET expansion port into a buffered bus that is in turn compatible with the 6502 industry standard KIM BUS serviced by the MTU K-1005 card file system. It can be used in place of the K-1008-6 PET Graphic Interface Board if MTU expansion is desired that is totally compatable with the KIM BUS. For instance, if you have a PET and a AIM-65, you may wish to use the K-1008 Visible Memory or graphics instead of the K-1008-6 since the K-1008 can be used also by the AIM-65. Then you would need the K-1007 series interface for the PET (the K-1008-6 includes interface circuitry onboard).

The K-1007-1 is a 6″ by 6″ printed circuit board containing all the electronic interface components: power supply, sync processor circuitry, video switcher between PET and the K-1008-P Visible Memory, and address combination logic to re-encode the upp 4 address bits into KIM BUS standard form. The board has one 22/44 position conector to accept any MTU expansion bus board. The board is mounted perpendicular to the K-1007-1 board. Additionally, a set of edge fingers are provided which can be used to mate with the K-1005-P card file for up to 4 board expansion (which can be powered by the power supply on the K-1007-1). The single connection to the board is by a 12″ long 60 wire ribbon cable pluggable on both ends. This cable mates with either the K-1007-2 or K-1007-3 connector board, depending on what type of PET you have. This allows the basic K-1007-1 board to work with either old or new PETs.

The board utilizes PET low voltage AC to provide +8 and +16 volts unregulated to the expansion boards. The video sync processor controls include horizontal position, vertical position, and height to center the Visible Memory image on the PET screen. The video switch selects PET video after reset or if memory location BFFF is accessed, and selects the Visible Memory image if location BFFE is accessed. PET addresses from 2000 through 7FFF and 9000 through AFFF are encoded into a contiguous range from 2000 through 9FFF. PET addresses from B000 through BFFF are translated to F000 through FFFF to take care of the MTU standard I/O page at FE. The board comes with a manual containing installation instructions, principles of operation, schematic diagrams, and connector pinouts.

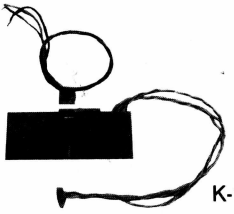
PET INTERFACES TO MTU BUS

PET-2001 CONNECTOR BOARD:
K-1007-2

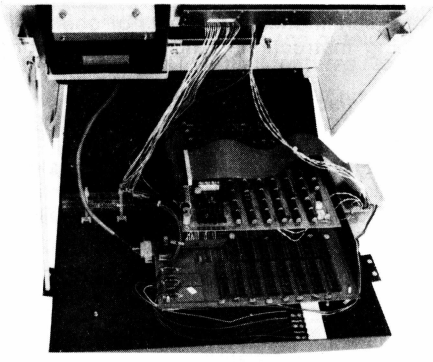

K-1007-2

This board has an 80 pin PC edge connector which plugs onto the PET memory expansion EDGE FINGERS (distinguishing feature of the OLD PET). The board mounts parallel to and in the same plane as the PET main logic board. In addition it has a connector to accept the PET CRT monitor cable (6 wires), a 6 wire cable with plug to mate with the PET main logic board video connector, 3 wires to solder to the PET main logic board for power, and a 60 pin ribbon cable connector to mate with the K-1007-1 or K-1008-6 cable. The PET memory expansion edge fingers are recreated on the opposite side of the board from the 80 pin connector, allowing use with competitive PET expansion products. The board is 2½ ″ wide and protrudes from the PET case.

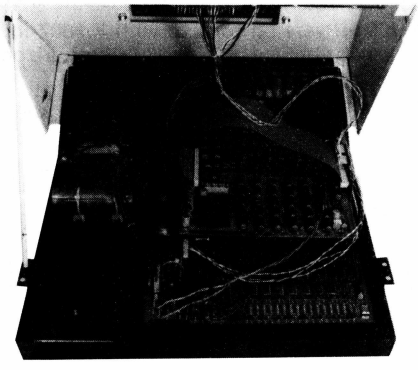
16/32K PET CONNECTOR BOARD:
K-1007-3


K-1007-3

This board mates with the "new" 16/32K and CBM PETs (this version of PET has the two 50 pin ribbon cable connector mounted 0.100 inch apart in the same horizontal line for the memory expansion port connectors, a connector to accpet the PET CRT monitor cable plug (6 wires), a cable with plug to mate with the PET main logic board video connector, and a 60-wire ribbon cable connector to mate with the K-1007-1 or K-1008-6 cable. In addition, open holes (signals prewired in PC) are provided on the board to mount two 50-pin ribbon cable connector "straight headers" which recreate the PET memory expansion port. These connectors are mounted 0.300 inch apart (not 0.100 inch as in the PET) so they may accept individual ribbon cables for mounting to competitive expansion products. This board plugs in perpendicular to the PET main logic board and is completely enclosed in the PET case.



OLD PET SHOWN
WITH K-1007-2
AND K-1008-6
INSTALLED



NEW PET SHOWN
WITH K-1007-3
AND K-1008-6
INSTALLED

K-1008 8K MEMORY/RASTER GRAPHIC DISPLAY GENERATOR

The MTU Visible Memory is a unique concept in microcomputer memory systems. The board is an 8K memory add-on to KIM BUS systems which includes the circuitry to simultaneously display the memory contents as 64,000 dots on a TV monitor. Unlike many other add-on memory boards, this one is designed for the KIM-bus and is merely connected in parallel with the expansion connector. The processor continues to run at full speed with no wait states, and no software overhead or CPU time is required to refresh the display. There is no snow or other visible interference on the screen when the display memory is being accessed by the processor (or any other time). Logic on the Visible Memory automatically refreshes the display.

The basic display format is 200 lines of 320 dots per line. This format coupled with the K-1008 software package makes the Visible Memory an exceptionally versatile mixed text and graphics display. The high resolution graphics capabilities make interaction possible with a degree of realism never before available on a microcomputer.

Extensive use of "LS" IC's and 4K dymanic memory IC's is responsible for the low power consumption and small size of the board. Problems experienced with dynamic memory in other systems are absent in this board due to the superior bus control architecture of the 6502 processor and MTU advanced circuit design. The circuity that generates the display pattern also refreshes the memory automatically as it scans.

The memory address can be jumper selected at any 8K boundary with the 8K memory block contiguous from the selected address. An extra jumper selectively disables the top or bottom half of the display thus allowing 4K to be used for program storage without showing up as a random pattern on the screen. The "Decode Enable" and "K7" signals needed for the KIM-1 to expand beyond 4K memory are generated by the board and need simply be connected to the proper pins of the KIM application connector. These signals are not used on the SYM and AIM processors. Up to four Visible Memory boards may be connected directly to an unbuffered KIM-bus.

For use with the K-1007-1 interface to the PET computer from Commodore, three wires must be added to the board edge fingers from ICs generating the video signals. This may be done by the user, or if desired, by MTU by ordering part number K-1008A-PET.

Manual: Complete hardware schematics, principles of operation, timing diagram, programming instructions, and troubleshooting guide.

Sockets: All Integrated circuits packs.

Display Format: 200 lines, 320 dots per line, non-interlace.

Scanning Frequencies: (derived from 1 MHz processor clock) Horizontal: 15,625 Hz, Vertical: 60.1 Hz. Required video bandwidth: 4 MHz. For 50 Hz operation, request MTU APPLICATION NOTE 3.

Output: 1.25 V p-p composite video into 70 ohms, sync negative.

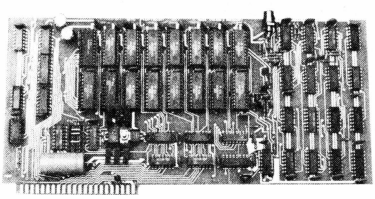
Adjustments: dot sync (prealigned on assembled units) on assembled units).

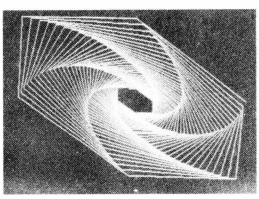
Power Requirements: unregulated +7.5V @ .25 amp, +16V @ .25 amp. (−5V for the memory chips is generated on board).

Size: 5″ high by 11″ wide exclusive of edge fingers.

K-1008-P version for use with K-1007 interfaces for PET use. This unit has 3 wires added to bring horizontal and vertical sync and video signals to the K-10076 board.

SEE ALSO: Application notes AN-2 and AN-3.





SOFTWARE FOR THE K-1008 VISIBLE MEMORY BOARD

GRAPHICS/TEXT ROUTINES GENERAL DESCRIPTION

This software package for the K-1008 Visible Memory is designed to provide the user with a library of utility graphic and text display oriented subroutines written in assembly language. By incorporating calls to these routines, the user can create and manipulate text and graphic images whose complexity is limited only by the 320 by 200 display matrix size. Most routines operate on X and Y coordinate arguments. In addition to the subroutine library, two demonstration programs are provided.

GRAPHIC FUNCTIONS:

Point plotting functions available in the package are Set Pixel, Clear Pixel, Flip Pixel, Write accumulator contents to Pixel address, and Load Pixel address contents to accumulator. The pixel location is by double-precision X and Y coordinates.

Line drawing functions available are draw line from X1:Y1 to X2:Y2 by turning the pixels on (white lines), by turning the pixels off (black lines) or by flipping the previous state of the pixels (exclusive-or function). The flip function will leave the state of the display unchanged (upon completion) if the same image is drawn twice. This allows the user to "move" an image through the display and leave the background unchanged. The total graphic routines require 500 bytes of memory.

TEXT FUNCTIONS:

The DCHAR routine is a software character generator. The character images have been carefully chosen for maximum legibility. The main character matrix is 5x7 and with decenders on lower case character, the effective matrix is 5x9. The character code is full ASCII. When called, DCHAR writes the indicated image with its upper left corner at the X1:Y1 coordinate.

The DTEXT routine accepts ASCII characters and formats them into text. It interprets ASCII control codes CR, LF, BS, DC1-DC4 (cursor movement), and SI/SO (baseline shift for sub/superscript). Text entry starts at the X1:Y1 coordinate which is updated following each call. An underline cursor is provided at the current location. The format is a 5X9 character matrix in a 6x11 field providing 18 lines of 53 characters. The sub/superscript operation is allowed on the full scharacter set. The ability to set margins (top, bottom, left, right) allows windowing to be done with text scrolling occuring only in the window, not in the outside area. Including the DCHAR subroutine, DTEXT with all features requires 2500 bytes of storage.

The SDTXT routine is a simplified version of DTEXT requiring only 1200 bytes with lower case, and 1000 bytes without. It interprets CR, LF, BS, FF, and provides the underline cursor at the current location. SDTXT uses line number and character column as its method of addressing. The font is a 5x7 matrix of upper case in a 6X9 field providing 22 lines of 53 characters. The lower case alpha characters are smaller versions of their upper case counterparts.

DEMONSTRATION PROGRAMS

Two machine language demonstrations are provided. LIFE Implements the game of Life in the full 320 by 200 matrix. The KIM keyboard may be used to set the initial colony pattern and control evoluion of the generations. SWIRL produces and infinite variety of patterns under the control of two parameters. It uses a simple difference equation algorithm.

BASIC INTERFACE GENERAL DESCRIPTION

Maximum utilization of a pixel (bit mapped) graphics display board like the K-1008 is enhanced by the use of a high level language such as BASIC. Software packages for use with the KIM, SYM, and AIM include the BASIC INTERFACE operations described below.

Positioning on the display is done in terms of X and Y coordinates. X can vary from 0 to 319 and Y can vary from 0 to 199. Position 0,0 is at the bottom left position of the screen. Four graphic variables called X1%, Y1%, X2%, and Y2% are set up at the beginning of the program using a BASIC statement. A point may then be

plotted anywhere on the screen by assigning the desired coordinates to X1% and Y1% and then executing the statement "Z = USR(2)". Other plotting functions available as USR commands are erase point, erase line, clear screen, and read the state of a point.

Text printed by BASIC PRINT statements may be placed wherever desired for axis labelling, etc. Text cursor control functions available with USR statements allow set and clear functions to be performed. Pokes into the cursor position bytes may be used for direct cursor positioning. Text can be displayed as full upper and lower case (using small caps for lower case — SDTXT) in a 5X7 matrix and gives a screen capacity of 22 lines of 53 characters each. All coordinates and cursor locations are verified and corrected if necessary thus giving fail-safe entry and execution of commands. Plotting and character generation speed is such that less than 10% of the execution time of a typical program is spent creating the display.

ALL PET GRAPHICS/TEXT SOFTWARE WITH BASIC INTERFACE: K-1008-3C

This software package contains the GRAPHIC/TEXT assembly language routines described earlier but contains a different BASIC INTERFACE for PET. All plotting and text functions described in the GRAPHIC/TEXT general description are available.

The BASIC INTERFACE uses GOSUB statements callable from PET BASIC preceeded by variable quantities input. For instance, to plot a line, the user would enter the following statements in the program:

```
GM% = 1      (0 = FLIP, 1 = ON, 2 = OFF)
X1 = A       (where A, B is the coordinates of the beginning
Y1 = B        endpoint and C,D is the coordinates of the ending
X2 = C        endpoint)
Y2 = D
GOSUB 106
```

The text display routine displays upper case in a 5x7 matrix and gives a screen capacity of 22 lines of 53 characters each. Failsafe operation from invalid X and Y values can be accomplished by the user either through BASIC checking or modification of the assembly language program (both given in the manual). Plotting and character generation speed is such that less than 20% of the execution time of a typical program is spent creating the display.

Using the package requires a K-1008-6 PET Graphic Interface Board or a K-1008-P Visible Memory, K-1007-1 PET interface (with associated PET connector board -2 or -3), and a PET with 8K or more memory. The graphics routines require only 1K bytes of memory. The text routines, if used, require an additional 1K. A relocation program is supplied to load the machine language routines for different PET memory sizes and for "OLD" or "NEW" PET ROMs.

The package comes supplied as assembled object code on cassette in PET format. A user manual describing use of the functions is included.

GRAPHICS/TEXT SOFTWARE FOR AIM-65: K-1008-5C

This software package is a combination of the TEXT/GRAPHICS and BASIC INTERFACE packages described on previous pages, configured for the AIM-65 single board computer. The BASIC INTERFACE contains the graphic routines embeded and comes assembled for a minimum 4K AIM (BAS04) and for a 4K AIM expanded with 16K (MTU K-1016) to a total of 20K (BAS20). The BASIC interface requires 2.5K of RAM and requires the AIM BASIC ROMs to function. Hooks have been provided for easy addition of the MTU GRAPHICS/TEXT PRINT package (K-1009-1C) to allow printing of the graphic and/or text images formed.

K-1008-5C con't

With use of this package, all text output from BASIC and from the AIM monitor appears on the Visible Memory screen (using the SDTXT routine) instead of the AIM 20 character display. Additionally, the package includes the full GRAPHICS, DTEXT, and SDTXT subroutines as separate assembled versions outside the BASIC interface programs. These programs require 1.2K byte for SDTXT, 2.5K byte for DTEXT, and 600 bytes for the GRAPHIC package. The SWIRL and LIFE demonstration programs provided require an additional 3K bytes of RAM to run, being executable on a 4K byte AIM.

The package is supplied with all the programs on cassette in AIM-65 readable object code form. Also included is a user's manual with full explanation of the commands and critical address locations of the subroutines. To use the package requires and AIM-65 with 4K, K-1000-5 power supply, K-1008 Visible Memory board, and a K-1005-A card file. Also the AIM BASIC ROMs if the BASIC interface is used.

AIM-65 GRAPHIC/TEXT SOFTWARE SOURCE CODE IN ASSEMBLABLE FORM: K-1008-5CS

The cassette is written in a format acceptable to the AIM-65 ROM assembler and thus allows the assembly language programmer to easily incorporate the software into application programs. It includes the code for SDTXT, DTEXT, and the graphics routines. The BASIC interface and demonstration programs are not available on the 107 program pages (54 printed pages). To run the package requires the same hardware as the K-1008-5C software and additionally the AIM assembler ROM. Purchase of this product requires signing an individual use license agreement prior to receiving the package.

GRAPHIC/TEXT SOFTWARE FOR KIM-1: K-1008-7C

This package is the GRAPHIC/TEXT subroutines and BASIC INTERFACE subroutines described on earlier pages assembled for the KIM-1 single board computer. It is the combination of the previous MTU products K-1008-1C (GRAPHIC/TEXT ROUTINES) and K-1008-2C (PATCHES TO MICROSOFT BASIC, Johnson Computer's early version).

In addition to the display handling routines, two keyboard routines are provided. These are greatly enhanced routines that allow full user control of program execution and text printing. They also allow effective use of upper and lower case characters with BASIC which normally cannot handle lower case alphabetics. One keyboard routine allows the use of an inexpensive unencoded keyboard while the other supports an ASCII encoded upper and lower case keyboard. The routines use the Visible Memory both for textual communication with BASIC (22 lines by 53 characters) and as a graphics display device.

The GRAPHICS/TEXT portion of the package requires the following hardware to run: a KIM-1, a K-1008 Visible Memory board, a K-1000 power supply, a CRT composite video monitor, and an expansion bus connector such as the K-1005-K card file. In addition, if the BASIC INTERFACE routines are used, a keyboard and a K-1016 16K memory board will be necessary. Required software other than this package is the Microsoft 9 Digit BASIC assembled at location 2000 **AND NOT EXTENDING BEYOND LOCATION 4260.** This is available fro Johnson Computer (Box 523, Medina, OH 44256) and was sold as their early version of BASIC. Later versions of their BASIC will not run with this package due to additional memory requirements on Johnson's part.

The SWIRL and LIFE demonstration programs reside in the standard KIM-1 1K byte RAM and assume that the Visible Memory resides at location 2000. Included with the BASIC INTERFACE routine is an instructive BASIC demonstration program which is an example of how to use the package with BASIC.

Memory requirements are: Microsoft BASIC locations 2000-4260, the BASIC interface routines locations 4261-49D7, keyboard routines in page 2 and page 3. For the TEXT/GRAPHIC subroutines: SDTXT locations 5B00-5FFF, Graphics and DTEXT 5500-5FFF. The package is supplied as assembled object code on cassette with the subroutines recorded in HYPERTAPE and in standard KIM-1 format. The documentation supplied is the full printed source code listing.

K-1020 PROTOTYPING BOARD

As many of our customers have requested, we now offer a prototyping board for KIM-bus systems. It is assembled with on-board + 5 Volt and + 12 Volt regulators and mounts in the K-1005 card file. Both Expansion and Application edge fingers are provided with gold plating and pads for wire-wrap post or direct wiring. The board has power bussing on both sides, all holes are plated through and it is constructed of standard glass epoxy material.

A universal hole pattern covers part of the board which allows 8, 14, 16, 18, 20, 22, 24, 28, 40 and even 64 pin IC's to be used. The maximum capacity is seventy-five 14 and 16 pin dips or up to sixteen 40 pin dips with space left for 14 smaller dips.

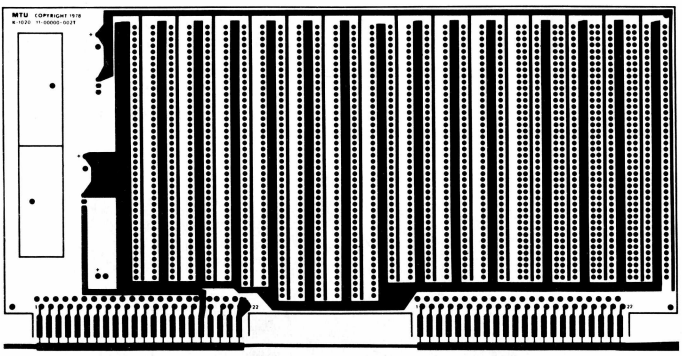
A heavy ground plane occupies most of the bottom side of the board while separate power planes for + 5V and + 12V intermesh on the top side. Bypass and input filter capacitors for the regulators are provided.

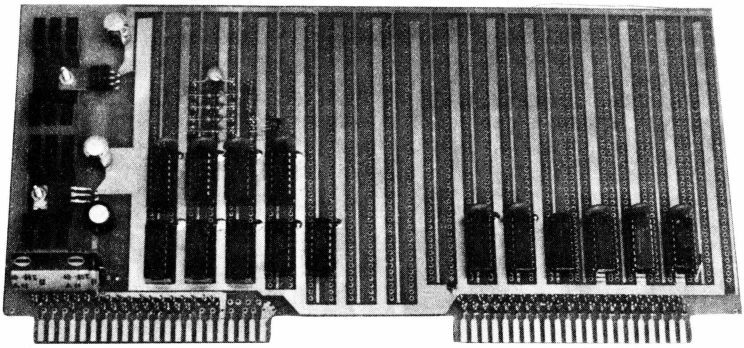
Size: 5" high by 11" wide exclusive of edge fingers.

Regulators: + 5 volts 1.2 Amp, volts .250 Amp.

Manual: The manual for this product is designed to allow the user to fully document the circuit which has been built on this board for future reference. The manual is bound and includes: 5 strips of paper 2" wide for glueing custom schematics in (once they are in final form), Expansion and Application bus signal names that are used, assembly layout sheet for component location and identification, and parts list sheet. In addition, an example schematic of an interface circuit to the KIM BUS and a schematic of the on-board power supply are provided.

Inclusions: Example schematic of interface circuit to the KIM-bus, layout assembly sheets, and power schematic and pinout designations.





THINGS TO COME

New product development is a continuous process at MTU and we have several exciting products at various stages of development. Although exact introduction dates have not yet been set, they are listed in approximate order of introduction.

ANALOG-TO-DIGITAL CONVERTER — This board is designed to convert an audio signal into a stream of 8 bit bytes which in turn can be sent to our K-1002 digital-to-analog converter boards to re-create the sound with good quality (50 dB signal/noise). The board will contain a full 8 bit ADC with a conversion time of 20 microseconds, a 3.5kHz sharp-cutoff lowpass filter, and a microphone preamplifier. Companion software will do sound digitizing, storage, and spectral analysis.

MUSIC COMPILER AND EDITOR — This is the badly needed "human interface" to our Instrument Synthesis music package. It will initially be implemented on the PET and will consist of three major parts. Part 1 will allow scores to be graphically entered and edited. Part 2 will allow instrument definitions to be graphically entered, edited, and auditioned. Part 3 is a music compiler which will translate a music language (which may be used in lieu of the graphic editor for long or complex scores) into code acceptable to the Instrument Synthesis package.

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